# *The Composite Conductor*

**Doug Johnson**

Energy Markets
3M Industrial Business

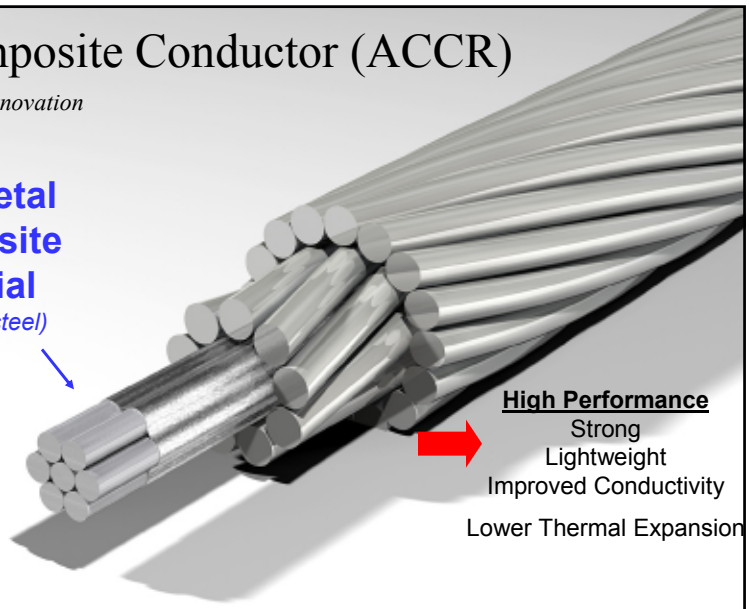
3M *Innovation*



## 3M Composite Conductor (ACCR)

*A Materials Innovation*

**New Metal Composite Material**
*(replaces steel)*

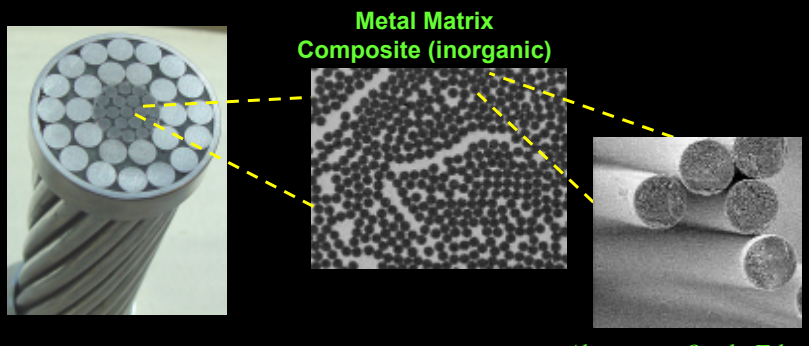


**High Performance**
Strong
Lightweight
Improved Conductivity

Lower Thermal Expansion

**Quick solution to increase capacity of existing transmission lines without need for new towers or a visual change to line**

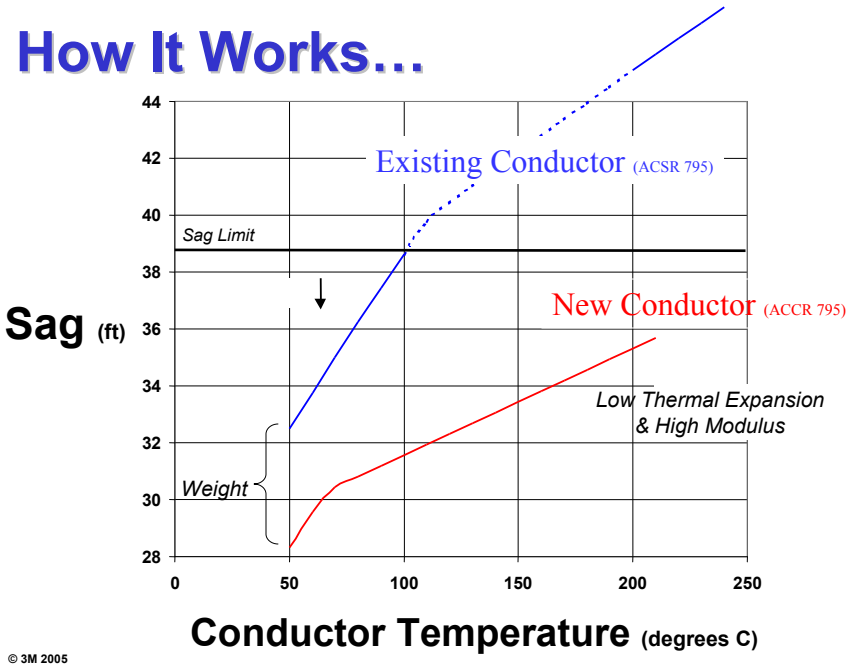
## Developed for Performance and Reliability



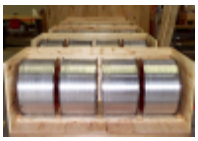

**Key Features:**

- *Improved properties*
- *Chemically compatible materials (stable)*
- *Fully hard aluminum*
- *Redundancy on strength (load sharing and construction)*
- *Safety factor on temperature*

## How It Works…



## ACCR is result of a multi-year US Dept of Energy Development Program



3M

WIRE ROPE

Nexans

energy.gov

Western Area Power Administration

UT-BATTELLE

NTRAC

ALCOA



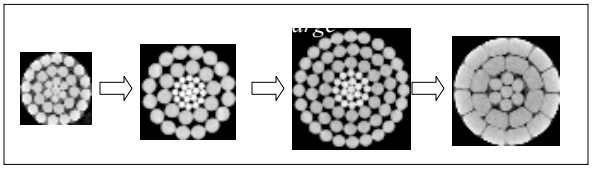
## **Focus on Reliability:** Conductor and Accessories Undergoing Wide Range of Laboratory Tests

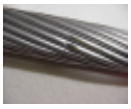
Strength
Stress-strain

Thermal
Expansion

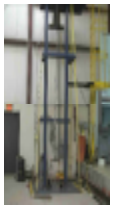
Short Circuit

Torsional
Ductility



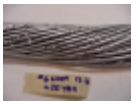


Drop Test

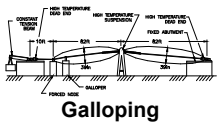


Axial
Impact

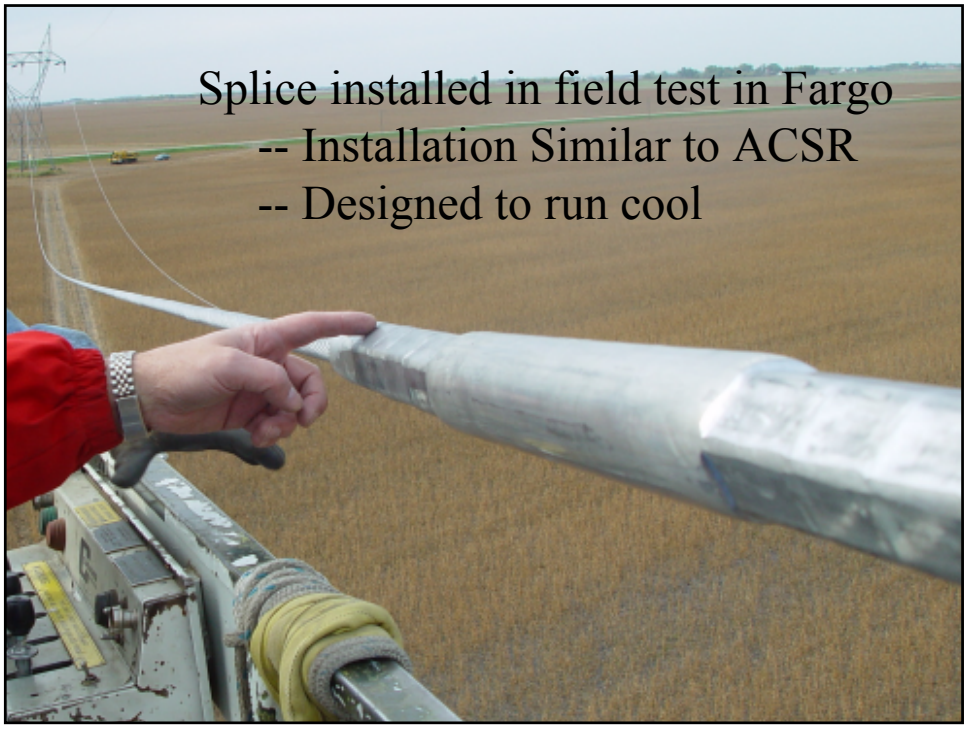
High Temperature testing



Shotgun



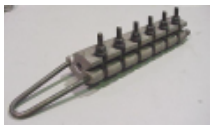
Galloping




## Alcoa Fujikura Ltd.

Stockbridge Dampers

Full-Tension Joints



Bolted Comealongs

Bolted Parallel Groove Clamp

Dead-end Hardware

Jumper Connectors

Repair Sleeves

Terminal Connectors

Conductor Accessories

| Conductor Testing | 477 | 795 | 1272 | 596TW | 675TW | 774(46/37) |
|---|---|---|---|---|---|---|
| Tensile Strength | √ | √ | √ | √ | √ | √ |
| Stress-Strain Curves | √ | √ | √ | √ | √ | √ |
| RT Creep | √ | √ | √ | n/a | n/a | |
| ET Creep | √ | n/a | n/a | n/a | n/a | |
| Impact | √ | √ | n/a | n/a | n/a | |
| Crush | √ | √ | n/a | n/a | n/a | |
| Torsion | √ | √ | n/a | n/a | n/a | √ |
| CTE | √ | √ | n/a | n/a | n/a | |
| Core strain f(T,S) | √ | n/a | n/a | n/a | n/a | |
| DC Resistance | √ | √ | √ | √ | | √ |
| Fault Current | √ | √ | n/a | √ | n/a | active |
| Lightning Strike | √ | √ | n/a | n/a | n/a | |
| Aeolian Vibration | √ | √ | √ | √ | n/a | **2005** |
| Sag | √ | √ | active | √ | √ | **2005** |
| Corrosion | n/a | √ | n/a | n/a | n/a | n/a |
| Sheave | active | √ | active | active | | active |
| Post-field test | √ | **2005** | **2005** | | √ | |

| Accessory Testing | 477 | 795 | 1272 | 596TW | 675TW | 774 |
|---|---|---|---|---|---|---|
| **Alcoa** | | | | | | 46/37 |
| DE Strength | √ | √ | √ | √ | √ | √ |
| Joint Strength | √ | √ | √ | √ | √ | 2005 |
| RT Sustained Load DE + Joint | √ | √ | √ | √ | √ | 2005 |
| ET Sustained Load DE + Joint | √ | √ | √ | √ | √ | 2005 |
| Current Cycle | √ | √ | √ | √ | n/a | |
| Dampers | √ | √ | √ | √ | n/a | √ |
| Repair Sleeve | √ | active | active | | | |
| **PLP** | | | | | | |
| DE Strength | √ | √ | √ | n/a | √ | active |
| Joint Strength | √ | √ | √ | | √ | |
| RT Sustained Load DE + Joint | √ | √ | √ | | active | 2005 |
| ET Sustained Load DE + Joint | √ | √ | √ | | √ | |
| Current Cycle | active | √ | | | | |
| Suspension - turn angle | √ | √ | n/a | n/a | n/a | 2005 |
| Suspension - unbalanced load | √ | √ | √ | √ | n/a | 2005 |
| Suspension - ET profile | √ | √ | √ | √ | n/a | 2005 |
| Galloping | √ | √ | √ | √ | n/a | 2005 |
| Aeolian Vibration | √ | √ | √ | √ | n/a | 2005 |
| Corona RIV | √ | √ | | | | |
| Spacer | | active | | | | |
| Repair Splice | √ | √ | | | active | |
| Post –field hi-temp | √ | 2005 | 2005 | | √ | |



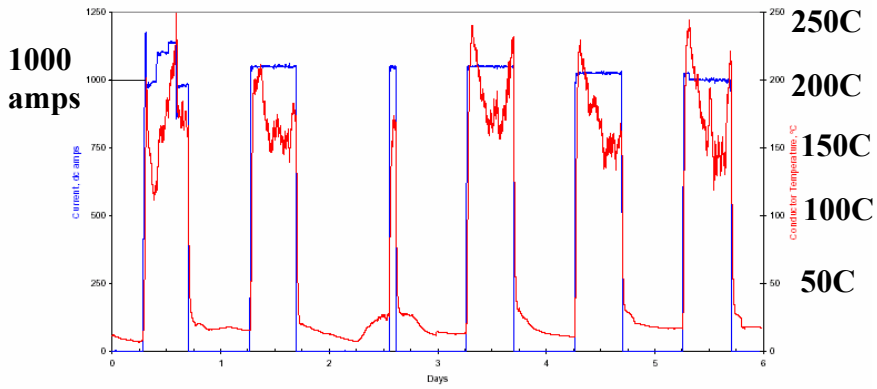
# High Temperature Testing

(210°C-continuous, 240°C-emergency)

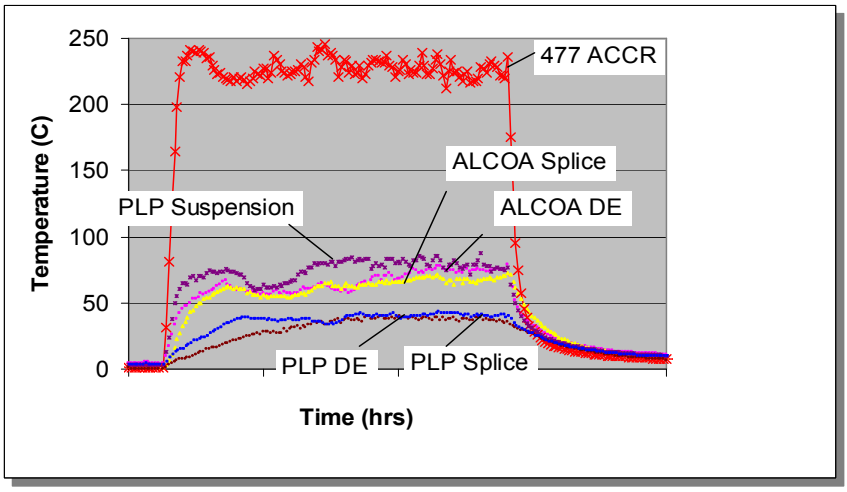
| Conductor | Accessories | Core | Al-Zr |
|---|---|---|---|
| thermal expand | current cycle | strength | aging |
| fault current | thermal profile | aging | resistance |
| sag | sustained load | creep | |
| thermal cycles | thermal cycles | thermal cycle | |
| sustained current | sustained current | thermal expand | |

# Over 100 CYCLES to 240C (464 F) (477 ACCR)

Fig. 1. Current and temperature profile for the 6 days of testing.



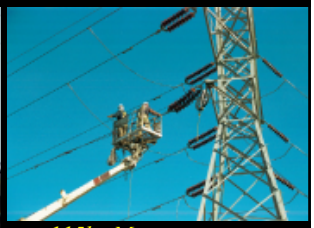

# Accessories Operate < 80 C when Conductor is fully loaded



## Field Installations

*46kv Hawaii*
*2002*

*230kv North Dakota*
*2002*

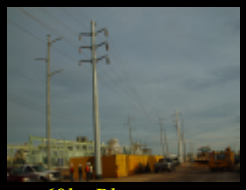


*115kv Minnesota*
*2001*

*ORNL Tennessee*
*2002*



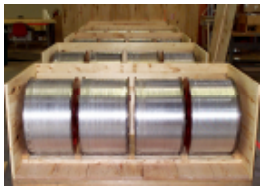
*230 kv Phoenix* *2004*



*69kv Phoenix* *2004*

*115kv Columbia River*
*2004*

## Available from 3M as total package



3

WIRE ROPE

Nexans

ALCOA

PLP

- Conductor & Accessories
- Installation Guidelines
- Laboratory Test Results
- Technical Support

## ACCR
Technical Documentation

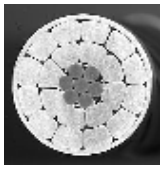
www.3M.com/ACCR



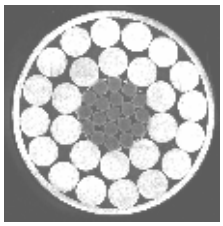


## 3Composite Conductor

ACCR 477

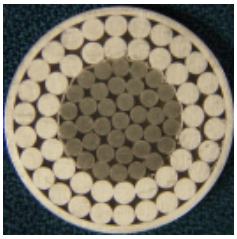


ACCR 675TW

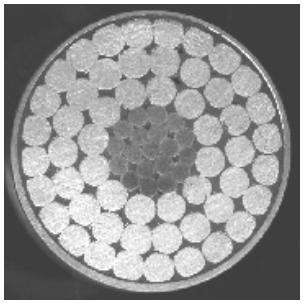


ACCR 795

**Unique Families of Conductors**
**-Full cable testing per family**
**-Full accessory testing per family**



ACCR 46/37 774



ACCR 1272


## Thermal Upgrade Application Guide

Competitive Performance: **AVOIDING REBUILDS**

| Replacement ACCR | Ampacity ACCR | Capacity Increase (x times ACSR) | | Equiv. ACSR Line |
|---|---|---|---|---|
| kcmil | amps | min | max | kcmils |
| 336 | 937 | 1.6 | 3.1 | 636 |
| 397 | 1,046 | 1.6 | 3.1 | 795 |
| 477 | 1,179 | 1.6 | 3.1 | 1,033 |
| 795 | 1,653 | 1.6 | 3.3 | 1,590 |
| 1033 | 1,940 | 1.7 | 3.4 | 2 X 636 |
| 1272 | 2,229 | 1.7 | 3.5 | 2 X 954 |
| 1590 | 2,586 | 1.7 | 3.5 | 2 X 1113 |


# Xcel Installation

***(Completed in 11 months)***

- Plant expansion was $100M investment
- Wetlands
- Challenging timelines

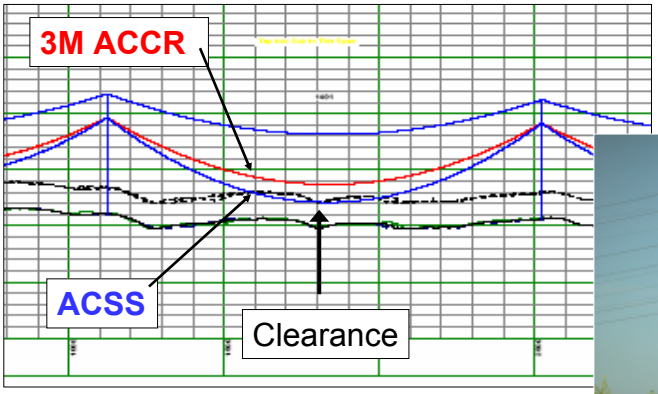


# Variety of Urban Terrain Types

***(Presented Permitting Challanges)***



# 3M Solution Avoided Tower Replacement




Saved the towers in sensitive wetland areas

**Supplied 33 Miles**

**Of ACCR 795**

## Simpler and Faster Than Rebuilding

***(Eight week installation)***

No bucket truck access

ATV access only

Lake Crossing



## Increased Capacity Without Environmental Impact or Visual Change to the Line

Energized June, 2005 (10 circuit miles)

- Significant increase in current capacity
- Met schedule
- Preserved sensitive wetland environment
- No disturbance to residential areas
- Cost effective

**Before** **After Installing 3M ACCR**

## Topock – Davis – Mead Expansion

*230 kV transmission line upgrade for the Western Area Power Administration*

80 Mile Line (240 miles ACCR)
Phase 1: 67 miles ACCR
Phase 2: 180 miles ACCR

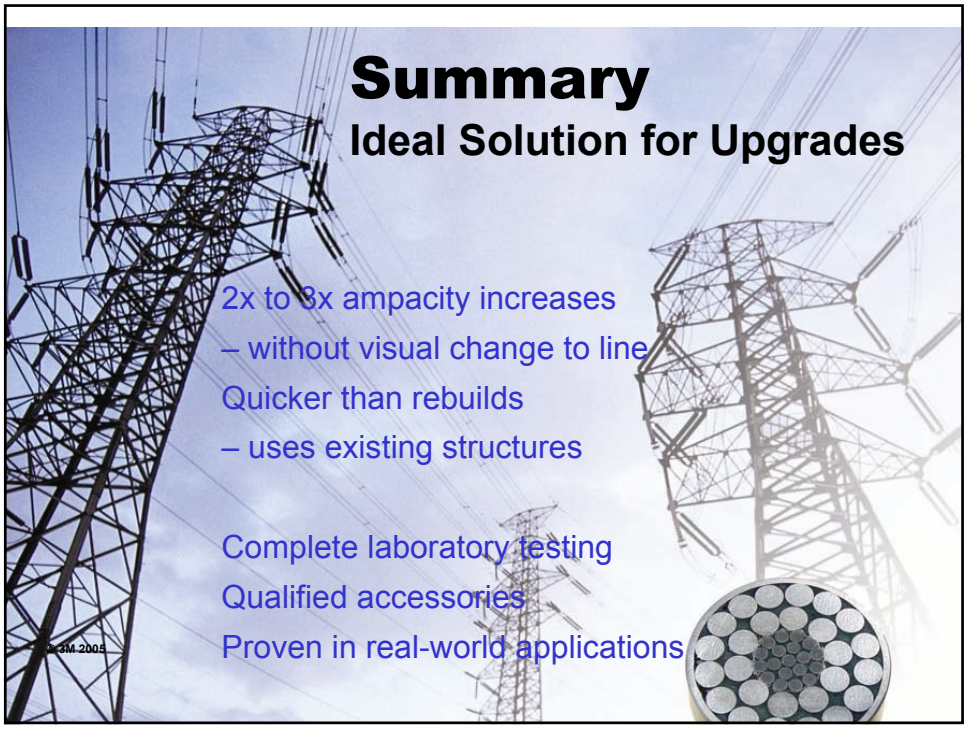
Value Proposition
-Eliminates Bottleneck
-Less Expensive Than Building New TL
-Endangered Species
-Simpler & Faster Permitting

## Bynum - Anniston

*Alabama Power*

10 circuit mile

Value Proposition
-Eliminates bottleneck (IPP connection)
-Avoids building new towers
-Saves critical time needed for other construction projects


Summary
Ideal Solution for Upgrades
2x to 3x ampacity increases
– without visual change to line
Quicker than rebuilds
– uses existing structures
Complete laboratory testing
Qualified accessories
Proven in real-world applications
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